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(54) Title of Invention

Light and pressure-proof fast-decomposed cast magnesium alloy

(57) Abstract of Disclosures

A light and pressure-proof fast-decomposed cast magnesium alloy can be used as a tripping ball material for a multi-stage sliding sleeve staged-fracturing technique. The light and pressure-proof fast-decomposed cast magnesium alloy is composed of the following components: 13 to 25% of Al, 2 to 15% of Zn, 0.1 to 5% of Fe, 0.05 to 5% of Cu, 0.05 to 5% of

Ni, 0 to 5% of Ag, 0.05 to 0.5% of Zr, 0.05 to 0.5% of Ti, and the remainder is Mg. The preparation method comprises the following steps: weighing the respective components according to the designed component proportions of the magnesium alloy; then first loading pure magnesium and pure aluminum into a smelting furnace, next loading pure zinc and an intermediate alloys of the other components into a magnesium-aluminum alloy melt after melting; increasing the temperature for melting, refining, degassing, waiting for a while and then casting in a protective atmosphere. The light and pressure-proof fast-decomposed cast magnesium alloy of the present invention is reasonable in component ratio, and simple in the production process; the light and pressure-proof fast-decomposed cast magnesium alloy can be obtained by controlling the components of the alloy; the alloy decomposition performance exceeds that of a traditional cast magnesium alloy; the demands of the multi-stage sliding sleeve staged-fracturing technique on the decomposition performance of the tripping ball material can be met; industrialized application can be achieved; application of the magnesium alloy in the field of exploitation of petroleum and gas is thus expanded.

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What is claimed is:

1. A light and pressure-proof fast-decomposed cast magnesium alloy, comprising the components at the weight percentages as follows:
Al: 13 to 25%,
Zn: 2 to 15%,
the remainder is Mg, and a sum of the weight percentages of the components is 100%.
2. The light and pressure-proof fast-decomposed cast magnesium alloy according to claim 1, further comprising the trace elements at the weight percentages as follows:
Fe: 0.1 to 5%,
Cu: 0.05 to 5%,
Ni: 0.05 to 5%,
Zr: 0.05 to 0.5%,
Ti: 0.05 to 0.5%; and a sum of the weight percentages of the components is 100%.
3. The light and pressure-proof fast-decomposed cast magnesium alloy according to claim 2, further comprising 0 to 5% by weight of trace element Ag, and the sum of the weight percentages of the components is 100%.
4. A method for preparing the light and pressure-proof fast-decomposed cast magnesium alloy according to any one of claims 1 to 3, comprising the following steps:
weighing the respective components according to the designed component proportions of the magnesium alloy; then first loading pure magnesium and pure aluminum into a smelting furnace, next loading pure zinc and an intermediate alloys of trace element components into a resulting magnesium-aluminum alloy melt after melting; increasing the temperature for melting, refining, degassing, waiting for a while and then casting in a protective atmosphere.
5. The method according to claim 4, characterized in that the melting temperature of pure magnesium and pure aluminum is from 700 to 730 °C.

6. The method according to claim 4, characterized in that the melting temperature of pure zinc and the intermediate alloys is from 740 to 780 °C.
7. The method according to claim 4, characterized in that the temperature for the steps of refining and degassing is from 720 to 750 °C, and the steps of refining and degassing are carried out by introducing argon or C₂Cl₆.
8. The method according to claim 4, characterized in that after waiting for a while, the temperature for casting is from 700 to 720 °C, and the casting protective atmosphere is argon or a mixture of SF₆ and air.
9. The method according to claim 4, characterized in that the intermediate alloys of trace element components are an Al-Fe intermediate alloy, an Al-Ni intermediate alloy, an Al-Cu intermediate alloy, an Al-Ag intermediate alloy, an Al-Zr intermediate alloy, and an Al-Ti intermediate alloy, and the intermediate alloys are heated to dry and then added to the magnesium-aluminum alloy melt.
10. The method according to claim 9, characterized in that in the light and pressure-proof fast-decomposed cast magnesium alloy, the content of the component aluminum is composed of the aluminum content in the intermediate alloys of trace element components and the aluminum content in the magnesium aluminum alloy melt.

Light and pressure-proof fast-decomposed cast magnesium alloy

Technical Field

[0001] The present invention discloses a light and pressure-proof fast-decomposed cast magnesium alloy, which can be used as a tripping ball material for a multi-stage sliding sleeve staged-fracturing technique, and belonging to the technical field of magnesium alloy preparation.

Background Art

[0002] Shale gas refers to the untraditional natural gas that is present in organic-rich mud shale and its interlayers, which is mainly in the form of adsorption or free state. Its composition mainly includes methane, which is a clean and highly efficient energy resource. In recent years, the United States has made breakthroughs in the technologies of shale gas exploration and development, and the output has grown rapidly. This has a major impact on the international natural gas market, as well as the world energy landscape. The world's major resource countries have increased their exploration and development of shale gas. The multi-stage sliding sleeve staged fracturing technology is a new oil and gas reservoir reconstruction technology developed in recent years in the area of oil and gas well engineering technology. It is mainly applied to the cracking production and capacity increasing revamp of directional well and horizontal well of shale gas and low permeability reservoir. According to the geological conditions of the stratum and the needs of reservoir development, the technology can be used to divide a horizontal well into several sections by means of a packer, and then a ground ball control device is used to sequentially push a series of tripping balls with gradually increased diameters into the well so as to open the sliding sleeve stage by stage, thus pressure-cracking the production rocks to form fracture channels for oil and natural gas fluids, to expand the oil drainage area of oil and gas production layers and improve oil and gas yield. One of the key parts of this technique is the tripping ball. The tripping ball has two main functions: 1) to open the sliding sleeve to fracturing the formation rock; and 2) to separate from the fracturing fluid and pressure. After the completion of all rock fracturing, it is necessary to depressurize the well tubing to facilitate the later production of the oil and gas well. In the past, the conventional method is to use the low-

layer pressure to push the ball back to the well opening, or use a drilling tool to drill the sliding sleeve ball seat and the tripping ball, so as to destroy them. However, one shortcoming of these methods is that due to the influence of formation pressure and on-site construction pressure, the tripping ball may be stuck and accordingly the tripped ball fails to be pushed out from the well. On the other hand, using a drilling tool to remove the tripping ball would delay the construction period and increase construction cost and the risks associated therewith. Therefore, the development of a tripping ball that can withstand the high pressure of fracturing construction and the high temperature at the bottom of the well, and has the feature of self-decomposition in the fluid environment of a well, can effectively reduce the construction risk and improve the construction efficiency. A U.S. patent discloses a method for preparing a composite material having a decomposable multilayer coated core-shell structure (U.S. Patent No. US2011/0132143 A1, 2011). It has been shown in this patent that an electroless plating process is applied on the surface of the particles of nanoscale core metal powders (such as magnesium, aluminum, zinc, manganese and the alloys thereof) to coat multiple layers of a nano-shell of different metals or metal oxides, such as Al, Ni, Al_2O_3 , and the like, and then the post-plating composite powder is sintered to form a nanocomposite material having certain decomposition feature. However, the above method requires plating a plurality of nanoscale metals or metal oxides on the surface of the nanoscale magnesium, aluminum, zinc, manganese and alloy powders thereof with high activity, which would greatly increase the production cost of the material and thus cannot be industrially produced. Moreover, the Chinese patent (Patent No. 201110328251.9) discloses “a new material tripping ball for opening a segmented fracturing tripping ball sliding sleeve.” Although the density of the material prepared in this patent is relatively low, this patent uses a polymer material to prepare a tripping ball, and thus the tripping ball material does not decompose in a high-temperature corrosive medium, which necessitates the use of a drilling tool to drill the tripping ball in a multi-stage sliding sleeve stage fracturing process, and thus greatly increasing the production costs.

[0003] The existing cast magnesium alloy is mainly represented by Mg-Al-Zn type magnesium alloys, and the AZ91D magnesium alloy is the most widely used. The main components of this alloy and the respective weight percentages are as follows: Al 8.3 to 9.7, Zn 0.35 to 1.0, Mn 0.15 to 0.5, and the remainder is magnesium. The compressive strength of the

alloy is less than 250 MPa, and the decomposition rate is extremely low ($\leq 5 \times 10^{-4} \text{ g.cm}^2.\text{h}^{-1}$) (Chinese Journal of Nonferrous Metals, 2007, Vol. 17, No. 2, p181), and thus unable to meet the requirements of light, pressure-proof and quick decomposition for a tripping ball material in the multi-stage sliding sleeve staged fracturing technology.

[0004] In order to reduce the production cost and prepare a light and pressure-proof fast-decomposed cast magnesium alloy that can be used as a tripping ball material, the inventors of the present invention propose a method for preparing a light and pressure-proof fast-decomposed cast magnesium alloy by means of optimizing the alloy composition design using a self-made flux containing a rare earth element and adopting a smelting casting method. A light metal material mainly refers to a material with a density below 4.5g/cm^3 , including aluminum and its alloys, magnesium and its alloys, titanium and its alloys, and lithium and its alloys. In our early studies, we found that the decomposition rate of aluminum and its alloys and titanium and its alloys in a 3% KCl solution at 93°C is less than $1 \times 10^{-5} \text{ g.cm}^{-2}.\text{h}^{-1}$, thus the decomposition performance requirement of the tripping ball material in the multistage sliding sleeve staged fracturing technology cannot be satisfied (it requires the decomposition rate in 3% KCl at 93°C to be greater than $0.02 \text{ g.cm}^{-2}.\text{h}^{-1}$). In addition, lithium and its alloys are highly active and can be easily oxidized, and thus cannot be effectively and safely prepared in the atmospheric environment.

[0005] Therefore, we select magnesium as the basis of our study; by means of adjusting the chemical composition and preparation process and using an industrial production method, a light and pressure-proof fast-decomposed cast magnesium alloy is prepared, which is able to meet the requirements for the decomposition of a tripping ball used in the multi-stage sliding sleeve staged-fracturing technique.

Summary of Invention

[0006] One object of the present invention is to overcome the deficiencies in the multi-stage sliding sleeve staged-fracturing technique currently used in shale gas exploitation and to provide a cast magnesium alloy with reasonable component ratio, simple production process and

effective decomposition, and a preparation method thereof, wherein the decomposition performance of the magnesium alloy exceeds the existing cast magnesium alloys.

[0007] The present invention is achieved by the following technical solutions:

[0008] a light and pressure-proof fast-decomposed cast magnesium alloy comprises the components at the following weight percentages:

[0009] Al: 13 to 25%,

[0010] Zn: 2 to 15%;

[0011] the remainder is Mg.

[0012] a light and pressure-proof fast-decomposed cast magnesium alloy further comprises the trace element components at the following weight percentages:

[0013] Al: 13 to 25%,

[0014] Zn: 2 to 15%,

[0015] Fe: 0.1 to 5%,

[0016] Cu: 0.05 to 5%,

[0017] Ni: 0.05 to 5%,

[0018] Ag: 0 to 5%,

[0019] Zr: 0.05 to 0.5%,

[0020] Ti: 0.05 to 0.5%, and the remainder is Mg.

[0021] A method for preparing the light and pressure-proof fast-decomposed cast magnesium alloy comprises the following steps:

[0022] weighing the respective components according to the designed component proportions of the magnesium alloy; then first loading pure magnesium and pure aluminum into a smelting furnace and increasing the temperature to 700 to 730 °C, next loading pure zinc and an intermediate alloys of trace element components into a resulting magnesium-aluminum alloy melt after melting, and increasing the temperature to 740 to 780 °C; after melting, lowering the temperature to 720 to 750 °C, introducing argon or using C_2Cl_6 in refining and degassing; next lowering the temperature to 700 to 720 °C, waiting for a while and then casting in a protective atmosphere of argon or a mixture of SF_6 and air.

[0023] In the method for preparing the light and pressure-proof fast-decomposed cast magnesium alloy according to the present invention, the intermediate alloys of trace element components are an Al-Fe intermediate alloy, an Al-Ni intermediate alloy, an Al-Cu intermediate alloy, an Al-Ag intermediate alloy, an Al-Zr intermediate alloy, and an Al-Ti intermediate alloy, and the intermediate alloys are heated to dry and then added to the magnesium-aluminum alloy melt.

[0024] In the method for preparing the light and pressure-proof fast-decomposed cast magnesium alloy according to the present invention, the content of the component aluminum is composed of the aluminum content in the intermediate alloys of trace element components and the aluminum content in the magnesium aluminum alloy melt.

[0025] With respect to the prior art, the present invention has the following advantages:

[0026] The present invention adopts a magnesium alloy with a high aluminum content (13 to 25% by weight) and a high zinc content (2 to 10% by weight), and further adds elements of Fe, Cu, Ni and Ag which can enhance the corrosion performance of the magnesium alloy, and

at the same time adds Zr, Ti element as grain refiners to improve the compressive strength of the formed material, in which the purpose of adding the high content of aluminum content is to produce a large amount of cathode phase, the β ($\text{Mg}_{17}\text{Al}_{12}$) phase and eutectic phase on the grain boundary of the magnesium alloy, and the magnesium matrix α phase functions as an anode phase, so that the matrix and the grain boundary of the magnesium alloy form a large amount of micro-batteries, which greatly accelerate the corrosion decomposition of magnesium alloy. However, the mass fraction of the added aluminum cannot exceed 25%, because excessive addition of aluminum would reduce the volume fraction of the anode phase, the α phase, thereby reducing the number of micro-batteries formed in the magnesium alloy. The purpose of adding a high content of zinc to the magnesium alloy is to increase the strength of the magnesium alloy, but excessive addition of zinc would reduce the volume fraction of the cathode phase, the β ($\text{Mg}_{17}\text{Al}_{12}$) phase in the magnesium alloy. Elements such as Fe, Cu, Ni, Ag, etc., in the magnesium alloy can form a large number of intermetallic composite micro-particles, which can improve the corrosion performance of the magnesium alloy, thereby promoting the decomposition of the magnesium alloy. The addition of the trace elements Zr and Ti can refine the magnesium alloy crystals, thereby increasing the compressive strength of the alloy. The room temperature tensile strength σ_b of the light and pressure-proof fast-decomposed cast magnesium alloy prepared by the invention is 130 to 180 MPa higher than that of the existing AZ91D magnesium alloy, and the decomposition rate at 70 °C in a 3% KCl solution is 60 to 200 times of that of the existing AZ91D magnesium alloy, and the decomposition rate at 93 °C in a 3% KCl solution is 50 to 200 times of that of the existing AZ91D magnesium alloy.

[0027] In light of the foregoing, the present invention has a reasonable composition ratio and a simple production process, and can effectively improve the overall strength and decomposition performance of magnesium alloy. By way of the smelting casting method and adjusting the composition and preparation process for the alloy, a light and pressure-proof fast-decomposed cast magnesium alloy is prepared, and its performance meets the requirements for a tripping ball material for a multi-stage sliding sleeve staged-fracturing technique. The present invention thus expands the application of magnesium alloy in the field of oil and gas exploitation and provides a cast magnesium alloy that can be used in practical industrial applications and a method for preparing the same.

Description of Embodiments

[0028] According to the characteristics of the present invention, a smelting casting method is employed to obtain an industrial casting magnesium alloy having a room temperature compressive strength exceeding that of the existing casting magnesium alloy by way of controlling the composition of the magnesium alloy. The decomposition performance in a high temperature potassium chloride solution (at a temperature of 70 °C or 93 °C in a potassium chloride aqueous solution with a mass fraction of 3%) significantly exceeds that of the existing ingot metallurgy magnesium alloy (such as the Mg-Al-Zn type AZ91D magnesium alloy). The specific embodiments are described as follows:

[0029] The alloy component ratio of the examples and the comparative example of the present invention are shown in Table 1 below. The performance indicators of the alloys prepared in the examples and the comparative example are shown in Table 2 below.

[0030] Comparative example 1

[0031] The comparative example alloy is AZ91D magnesium alloy. The chemical composition of the alloy is as follows:

[0032] Mg-9Al-1Zn-0.3Zr-0.1Mn (mass fraction), the components of the alloy (raw materials are pure aluminum, pure magnesium, Al-4Zr intermediate alloy, Al-10Mn intermediate alloy and pure zinc) are melted in a medium frequency induction resistance furnace, and then refined with C_2Cl_6 , the product is allowed to stand for a while, and then the slag is taken out and cast into a billet with an iron mold under argon protection.

[0033] Example 1

[0034] The composition of the alloy and the respective percentages by weight are as follows:

[0035] 13% Al-2% Zn-0.1% Fe-5% Ni-2.5% Ag-0.5% Ti-0.5% Zr, and the remainder is Mg.

[0036] The preparation method is as follows: first pure magnesium and pure aluminum are loaded into a smelting furnace and the temperature is increased to 700 °C, after melting, an Al-Fe intermediate alloy, an Al-Ni intermediate alloy, an Al-Ag intermediate alloy, an Al-Zr intermediate alloy, an Al-Ti intermediate alloy and pure zinc, which have been heated, are next added into the resulting magnesium-aluminum alloy melt, and at the same time the temperature is raised to 740 °C; after melting, the temperature is lowered to 720 °C, argon is then introduced in a degassing treatment; and the temperature is next lowered to 700 °C, the sample is allowed to stand for a while, and then cast under the protection of argon, and then cooled.

[0037] Example 2

[0038] The composition of the alloy and the respective percentages by weight are as follows:

[0039] 15% Al-5% Zn-0.5% Fe-0.1% Ni-0.1% Ti-0.1% Zr, and the remainder is Mg.

[0040] The preparation method is as follows: first pure magnesium and pure aluminum are loaded into a smelting furnace and the temperature is increased to 730 °C. After melting, an Al-Fe intermediate alloy, an Al-Ni intermediate alloy, an Al-Zr intermediate alloy, an Al-Ti intermediate alloy and pure zinc, which have been heated, are next added into the resulting magnesium-aluminum alloy melt, and at the same time the temperature is raised to 760 °C; after melting, the temperature is lowered to 730 °C. Argon is then introduced in a degassing treatment; and the temperature is next lowered to 710 °C; the sample is allowed to stand for a while, and then cast under the protection of a mixture of SF₆ and air, and then cooled.

[0041] Example 3

[0042] The composition of the alloy and the respective percentages by weight are as follows:

[0043] 20% Al-10% Zn-5% Fe-2.5% Ni-2.5% Cu-5% Ag-0.25% Ti-0.25% Zr, and the remainder is Mg.

[0044] The preparation method is as follows: first pure magnesium and pure aluminum are loaded into a smelting furnace and the temperature is increased to 715 °C. After melting, an Al-Fe intermediate alloy, an Al-Ni intermediate alloy, an Al-Cu intermediate alloy, an Al-Ag intermediate alloy, an Al-Zr intermediate alloy, an Al-Ti intermediate alloy and pure zinc, which have been heated, are next added into the resulting magnesium-aluminum alloy melt, and at the same time the temperature is raised to 780 °C; after melting, the temperature is lowered to 750 °C, argon and a refining agent C_2Cl_6 are then introduced in a degassing treatment; and the temperature is next lowered to 700 °C, the sample is allowed to stand for a while, and then cast under the protection of argon, and then cooled.

[0045] Example 4

[0046] The composition of the alloy and the respective percentages by weight are as follows:

[0047] 18% Al-8% Zn-2.5% Fe-2.0% Ni-5% Cu-1% Ag-0.3% Ti-0.15% Zr, and the remainder is Mg.

[0048] The preparation method is as follows: first pure magnesium and pure aluminum are loaded into a smelting furnace and the temperature is increased to 715 °C. After melting, an Al-Fe intermediate alloy, an Al-Ni intermediate alloy, an Al-Cu intermediate alloy, an Al-Ag intermediate alloy, an Al-Zr intermediate alloy, an Al-Ti intermediate alloy and pure zinc, which have been heated, are next added into the resulting magnesium-aluminum alloy melt, and at the same time the temperature is raised to 750 °C; after melting, the temperature is lowered to 730 °C; a refining agent C_2Cl_6 is then used in a degassing treatment; and the temperature is next

lowered to 710 °C; the sample is allowed to stand for a while, and then cast under the protection of argon, and then cooled.

[0049] Example 5

[0050] The composition of the alloy and the respective percentages by weight are as follows:

[0051] 20% Al-5% Zn-0.8% Fe-0.05% Ni-0.05% Cu-0.05% Ti-0.1% Zr, and the remainder is Mg.

[0052] The preparation method is as follows: first pure magnesium and pure aluminum are loaded into a smelting furnace and the temperature is increased to 730 °C. After melting, an Al-Fe intermediate alloy, an Al-Ni intermediate alloy, an Al-Cu intermediate alloy, an Al-Zr intermediate alloy, an Al-Ti intermediate alloy and pure zinc, which have been heated, are next added into the resulting magnesium-aluminum alloy melt, and at the same time the temperature is raised to 750 °C; after melting, the temperature is lowered to 730 °C. Argon is then used in a degassing treatment; and the temperature is next lowered to 720 °C; the sample is allowed to stand for a while, and then cast under the protection of argon, and then cooled.

[0053] Example 6

[0054] The composition of the alloy and the respective percentages by weight are as follows:

[0055] 15% Al-6% Zn-1.5% Fe-0.2% Ni-1% Cu-2% Ag-0.15% Ti-0.1% Zr, and the remainder is Mg.

[0056] The preparation method is as follows: first pure magnesium and pure aluminum are loaded into a smelting furnace and the temperature is increased to 720 °C, after melting, an Al-Fe intermediate alloy, an Al-Ni intermediate alloy, an Al-Cu intermediate alloy, an Al-Ag

intermediate alloy, an Al-Zr intermediate alloy, an Al-Ti intermediate alloy and pure zinc, which have been heated, are next added into the resulting magnesium-aluminum alloy melt, and at the same time the temperature is raised to 770 °C; after melting, the temperature is lowered to 740 °C; a refining agent C₂Cl₆ is then used in a degassing treatment; and the temperature is next lowered to 700 °C; the sample is allowed to stand for a while, and then cast under the protection of a mixture of SF₆ and air, and then cooled.

[0057] Example 7

[0058] The composition of the alloy and the respective percentages by weight are as follows:

[0059] 25% Al-10% Zn-1% Fe-0.5% Ni-0.1% Cu-0.5% Ti-0.05% Zr, and the remainder is Mg.

[0060] The preparation method is as follows: first pure magnesium and pure aluminum are loaded into a smelting furnace and the temperature is increased to 730 °C. After melting, an Al-Fe intermediate alloy, an Al-Ni intermediate alloy, an Al-Cu intermediate alloy, an Al-Ag intermediate alloy, an Al-Zr intermediate alloy, an Al-Ti intermediate alloy and pure zinc, which have been heated, are next added into the resulting magnesium-aluminum alloy melt, and at the same time the temperature is raised to 760 °C; after melting, the temperature is lowered to 730 °C. Argon and a refining agent C₂Cl₆ are then used in a degassing treatment; and the temperature is next lowered to 710 °C; the sample is allowed to stand for a while, and then cast under the protection of a mixture of SF₆ and air, and then cooled.

[0061] Table 1 Main chemical components of the cast alloy of the present invention (in weight percentages)

Alloy	Al	Zn	Fe	Ni	Cu	Ag	Ti	Zr	Mn	Mg
Comparative example 1	9.00	1.00	0	0	0	0	0	0.01	0.03	remainder

[0062]

(AZ91D)										
Example 1	13	1.3	0.1	5	0	2.5	0.5	0.5	0	remainder
Example 2	15	5	0.5	0.1	0	0	0.1	0.1	0	remainder
Example 3	20	10	5	2.5	2.5	5	0.25	0.25	0	remainder
Example 4	18	8	2.5	2.0	5	1	0.3	0.15	0	remainder
Example 5	20	5	0.8	0.05	0.05	0	0.05	0.1	0	remainder
Example 6	15	6	1.5	0.2	1	2	0.15	0.1	0	remainder
Example 7	25	10	1	0.5	0.1	0	0.5	0.05	0	remainder

[0063] Table 2 Room temperature compressive strength and high temperature decomposition rate of the cast alloy of the present invention

[0064]

	Room temperature tensile strength σ_b (MPa)	Decomposition rate at 70 °C in 3% KCl solution ($\text{g}\cdot\text{cm}^{-2}\cdot\text{h}^{-1}$)	Decomposition rate at 93 °C in 3% KCl solution ($\text{g}\cdot\text{cm}^{-2}\cdot\text{h}^{-1}$)
Comparative example 1	232	0.00026	0.0005
Example 1	360	0.035	0.074
Example 2	385	0.015	0.045
Example 3	410	0.013	0.036
Example 4	375	0.034	0.058
Example 5	392	0.025	0.048
Example 6	365	0.021	0.063
Example 7	387	0.036	0.057

[0065] When comparing the performance parameter values of the examples with the comparative examples, it can be seen that the compressive strength of the cast magnesium alloy prepared in the present invention is significantly higher than that of the alloy of the comparative examples, and at both 70 °C and 93 °C in a 3% KCl solution, the decomposition rate of the present invention is significantly higher than that of the comparative example alloy, and can meet the performance requirements of a light and pressure-proof fast-decomposed cast

magnesium alloy used as a tripping ball material in the multi-stage sliding sleeve staged-fracturing technique.

TRANSLATION DECLARATION

I, Qiang Li, a translator for Morningside IP, hereby declare that the attached translation is, to the best of my knowledge and belief, a true and accurate translation from Chinese to English of the document received by this office and designated as Publication No. CN 103343271 A and bearing a publication date of October 9, 2013.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements are made with the knowledge that false and willful statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements and the like may jeopardize the validity of the submission.

Date: June 23, 2020



Qiang Li